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ASIA SHANGHAI

A Flexible Operated Li-ion Battery Management System for Motor Drives in Electric Vehicle Applications

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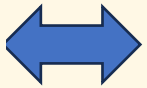
Outline of the presentation

- Overview of the problem
- Aim of the project
- Proposed hybrid Energy Storage System
- Equalization and Energy Support Algorithms
- Experimental results
- Conclusions

Overview of the problem

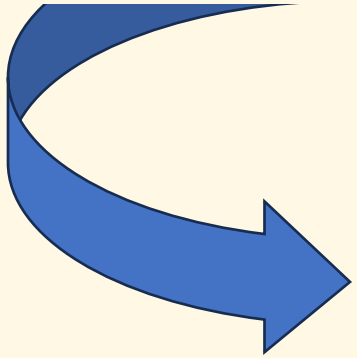
The Li-ion batteries concentrate several ***competitive advantages*** against other battery chemistries, such as:

- low self-discharge characteristics,
- high discharge/charge rate of current, and
- high-energy density



However, they ***have several drawbacks***, such as:

- the limited calendar life,
- safety issues,
- high cost and also,
- their performance should be carefully monitored and controlled, since they are sensitive to temperature, overcurrent and overvoltage/undervoltage



Objectives

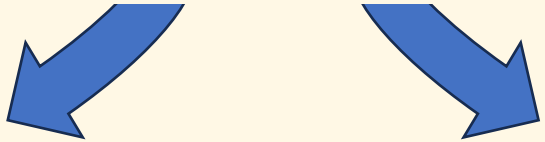
- protection of the Li-ion batteries lifespan and
- reduction of the charging time to reach 80% SoC (state-of-charge) in less than 20min

Overview of the problem

The problem ….

Li-ion batteries (LiBs) are ***the main energy storage media*** for several applications

They are the ***cause of several problems*** that they are resulted from the need for withdrawal and recycling



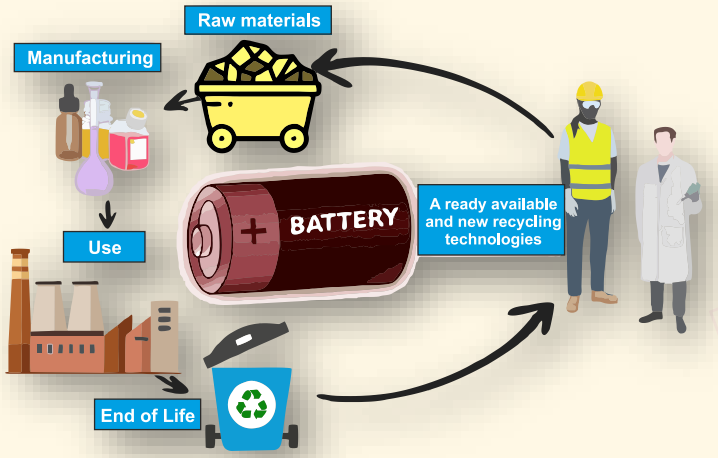
During 2020, Li-ion batteries withdrawal from electric vehicles is more than 1GWh energy capacity

it is estimated to be increased to:

- 15GWh in 2025 and
- 110 to 230GWh in 2030

Serious ***environmental*** and ***economic*** problem that will continue to expand every year

Overview of the problem



Solutions

Correct recycling of the batteries

- Energy cost for recycling
- Lithium obtaining through recycling has reduced quality compared that from mining
- Increased need for battery recycling

Reuse as 2nd Life batteries

Although it does not solve the problem

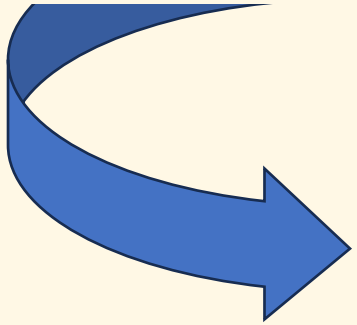
… it provides significant possibilities for better management

- **Categorize** according to the applications to achieve better utilization of their energy potential
- **Apply special techniques** for performance improvement and protection of the lifespan
- The ***cost of a 2nd life battery should be lower*** than a new one

Overview of the problem

Since the nominal voltage of a Li-ion battery cell is relatively low, ...several cells are usually ***series connected*** to provide the needed voltage.

… the reason for ***imbalance problems*** between the battery cells which are owed to differences in the operating characteristics, such as self-discharge rate, coulomb efficiency, and energy capacity.
The above, along with a potential increase in the internal resistance may lead to considerable ***reduction of the energy storage and power response capabilities***.



- to reduce the imbalances between the cell operation and
- keep their operation within acceptable limits of temperature, current, and voltage

Overview of the problem

Cell-to-cell equalization methods:

- ***Dissipative*** → the equalization energy is ***consumed*** by an ohmic resistance
- ***Non-dissipative*** → the equalization energy is ***exploited*** by the other cells of a battery stack

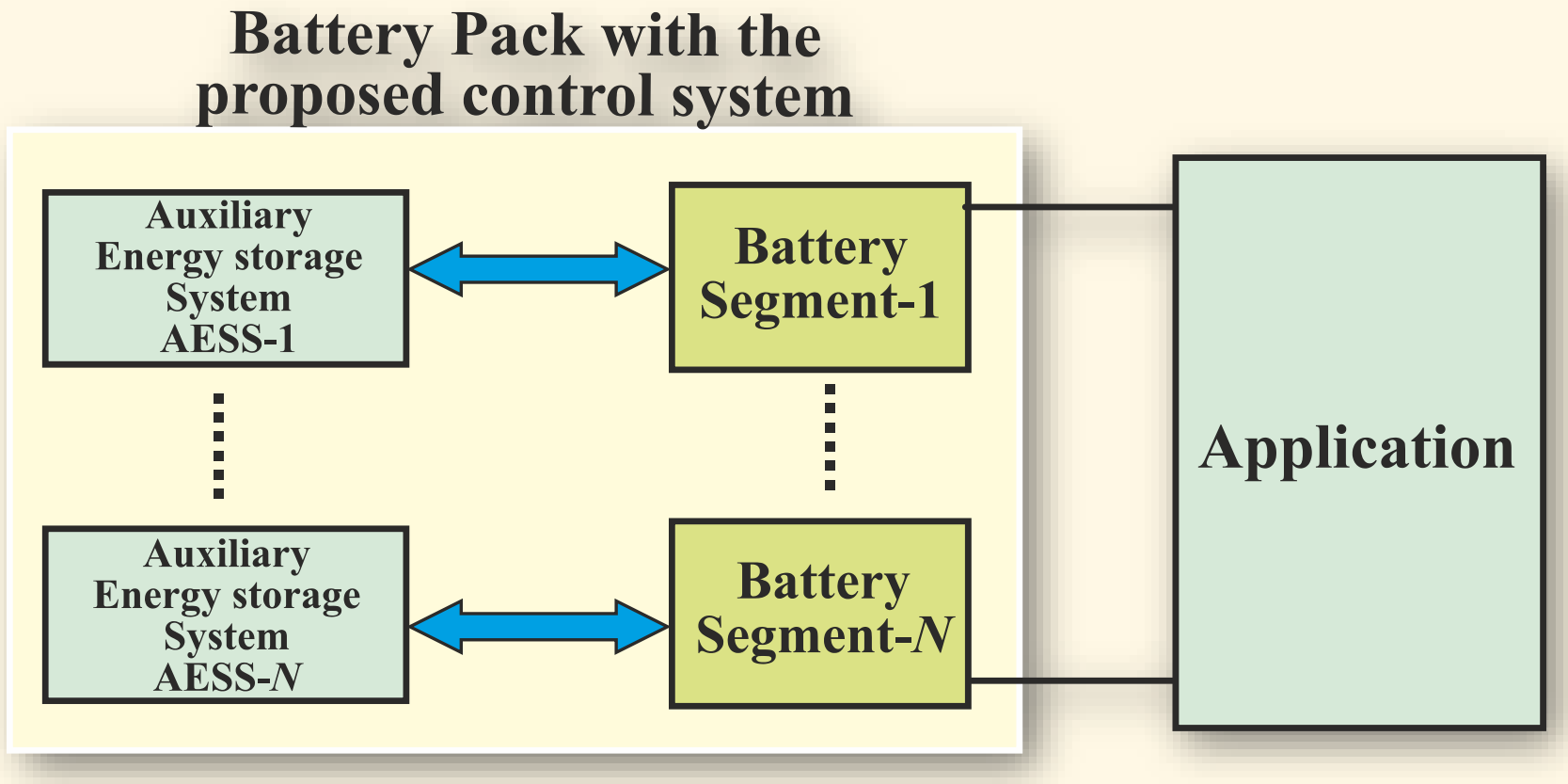
Common characteristic for their implementation
… is the requirement for the real-time knowledge of the battery cells parameters (SoF, SoC, SoH).

From the ***impedance***, several useful information for the electrochemical condition of a Li-ion battery cell can be extracted.

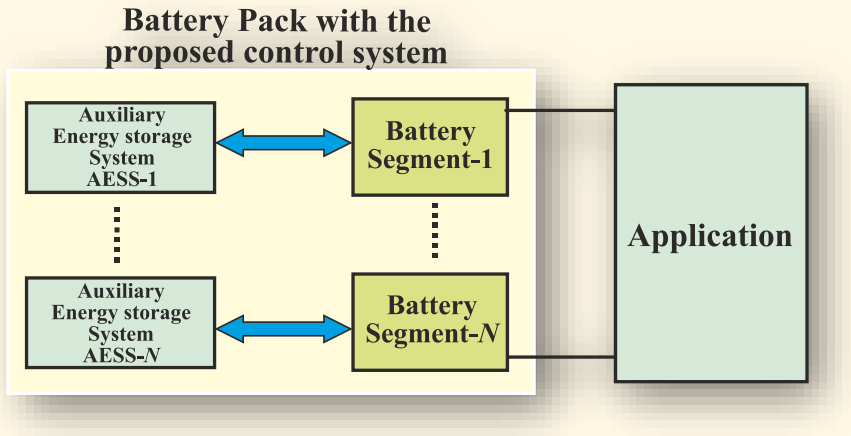
It can be estimated through the ***Electrochemical Impedance Spectroscopy (EIS) technique***
- ***single frequency*** and
- ***broadband***.

Aim of the research project

Proposed hybrid Battery-Supercapacitors system



Aim of the research project

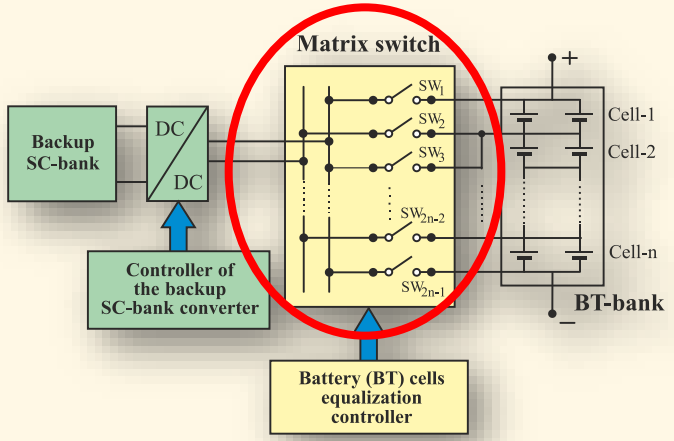


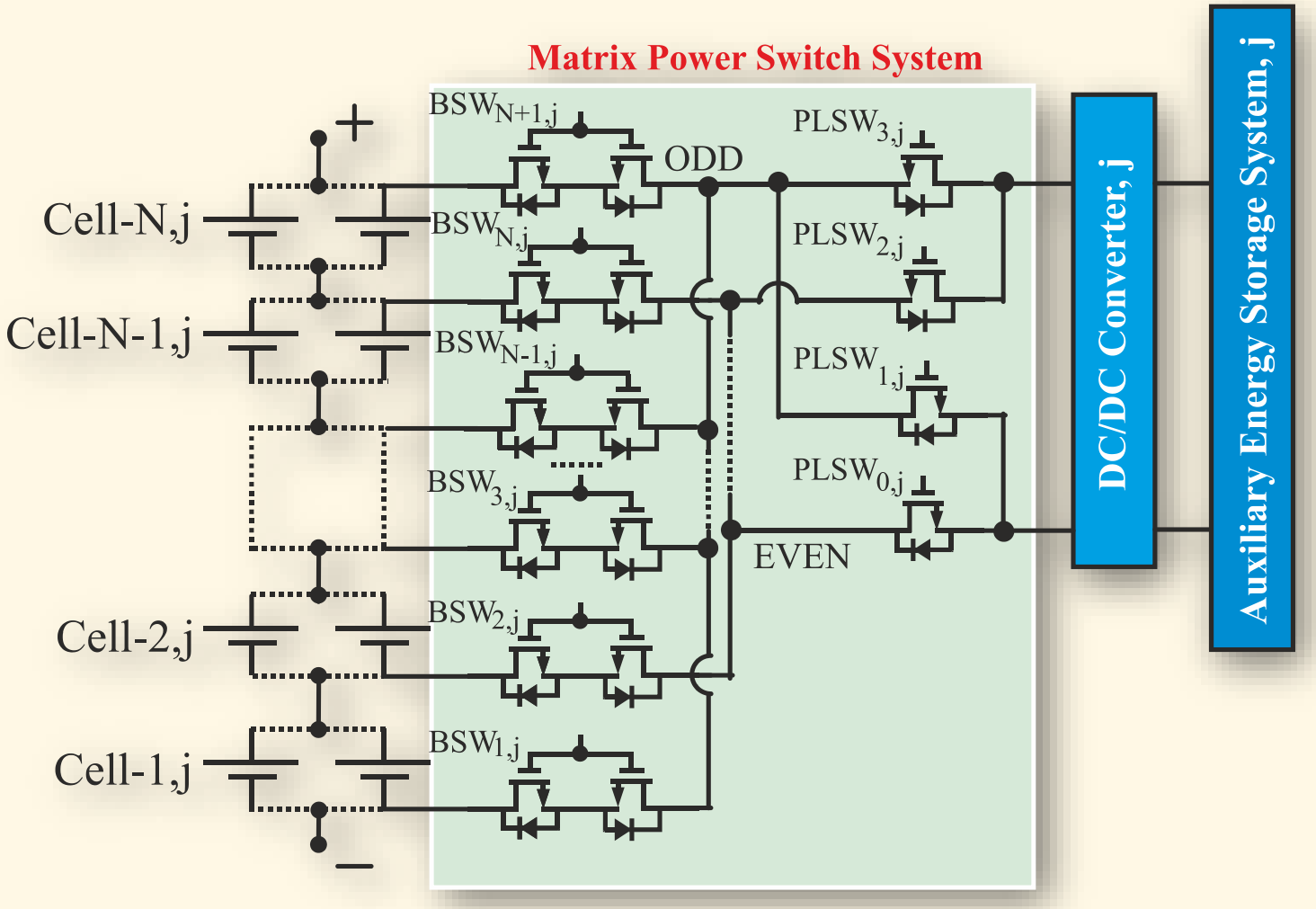
Characteristics:

- **It is a hybrid energy storage system** that consists of Li-ion batteries for the main energy reservoir in back-to-back connection with an *auxiliary energy storage system* (AESS) of supercapacitors (SCs) or Li-ion battery cells.

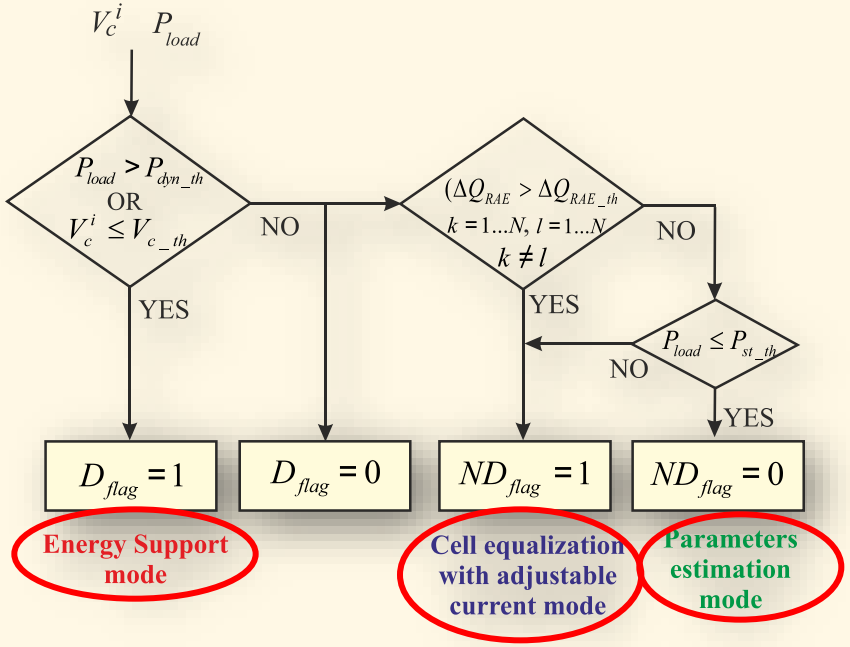
- **The auxiliary energy storage system:**
  - *improves the battery cell-to-cell equalization*,
  - *provides energy support to any weak or problematic cells* and
  - *enhances the dynamic performance* of the battery.

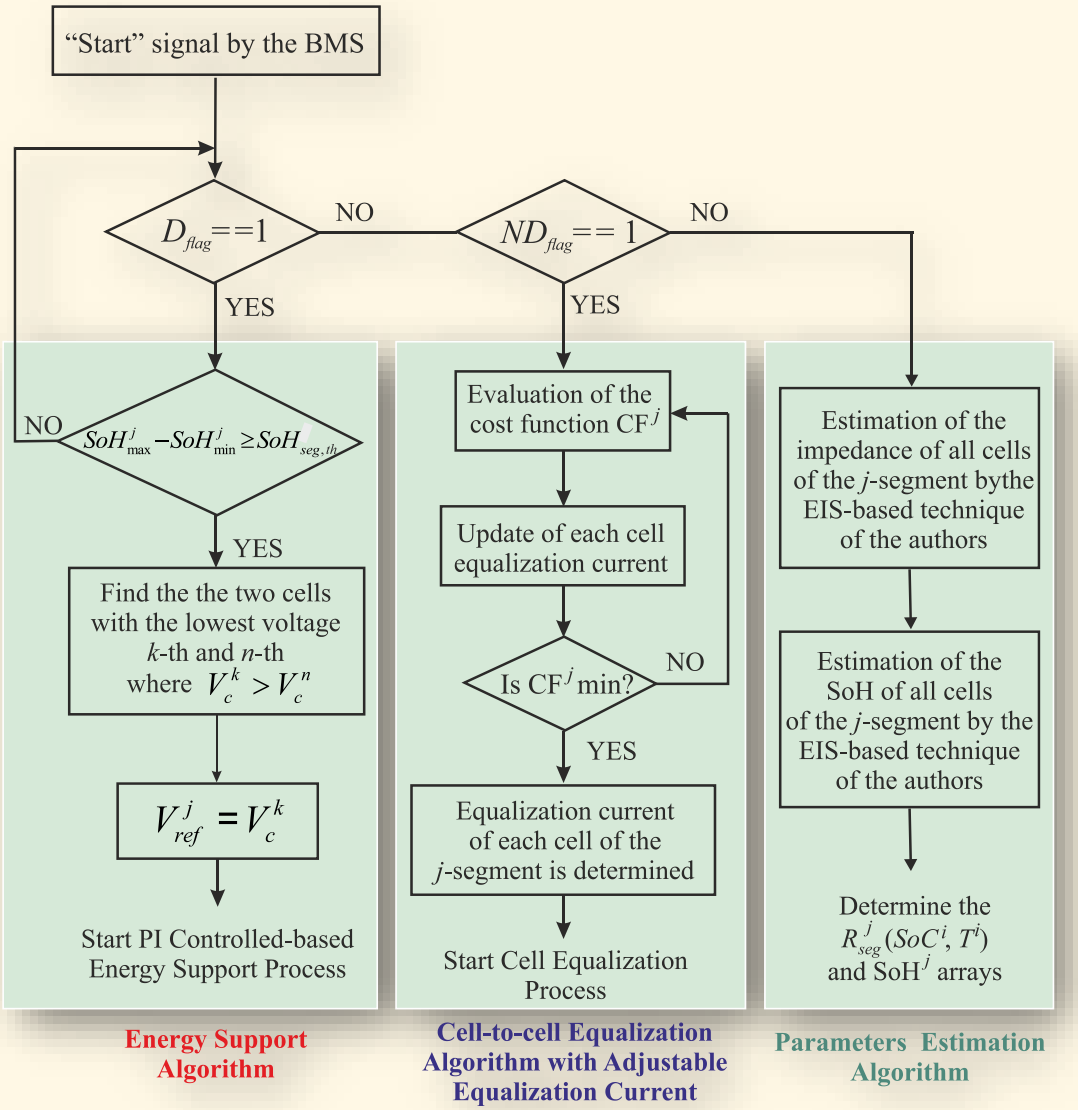
Proposed hybrid Energy Storage System



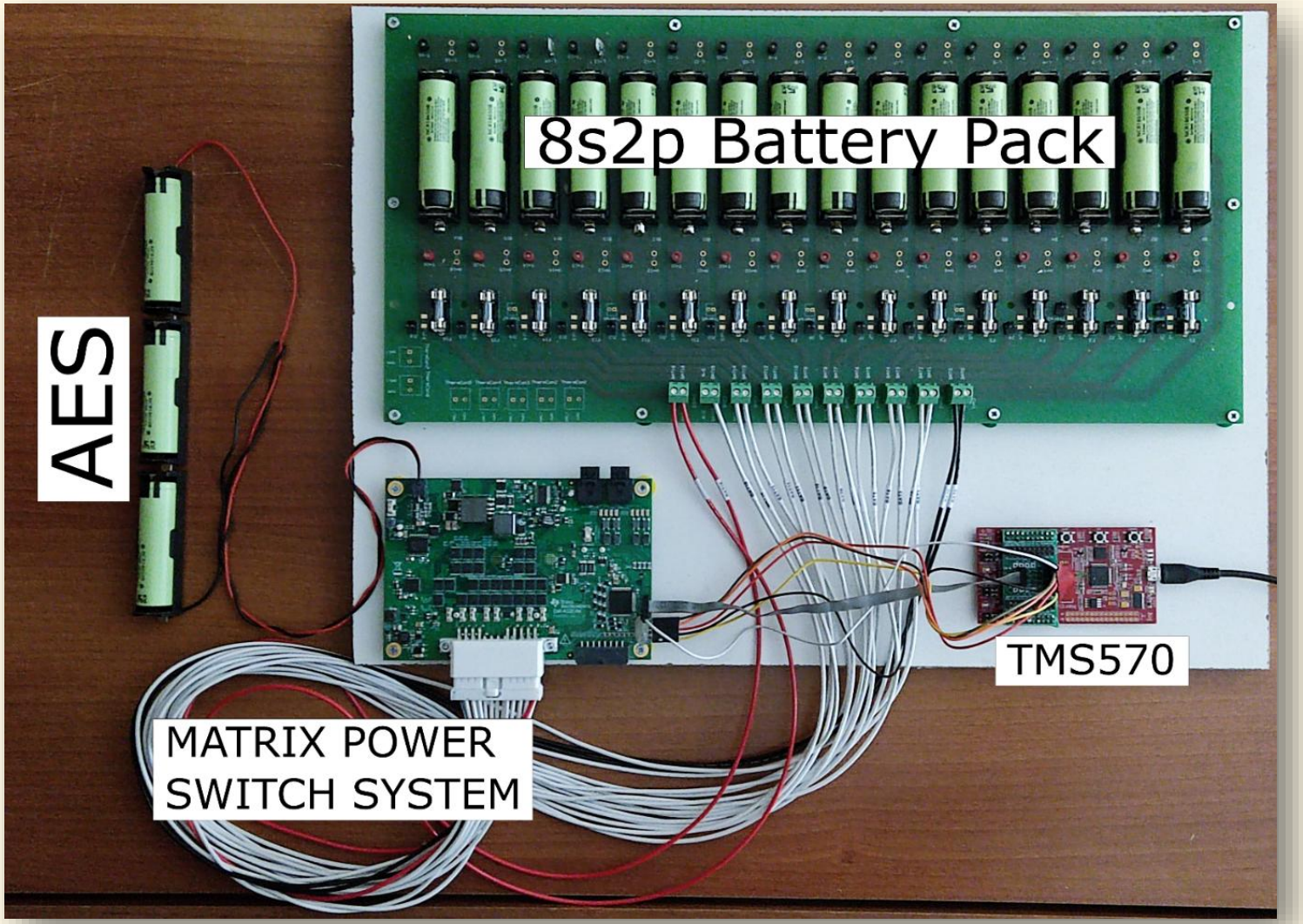


Equalization and Energy Support Algorithms



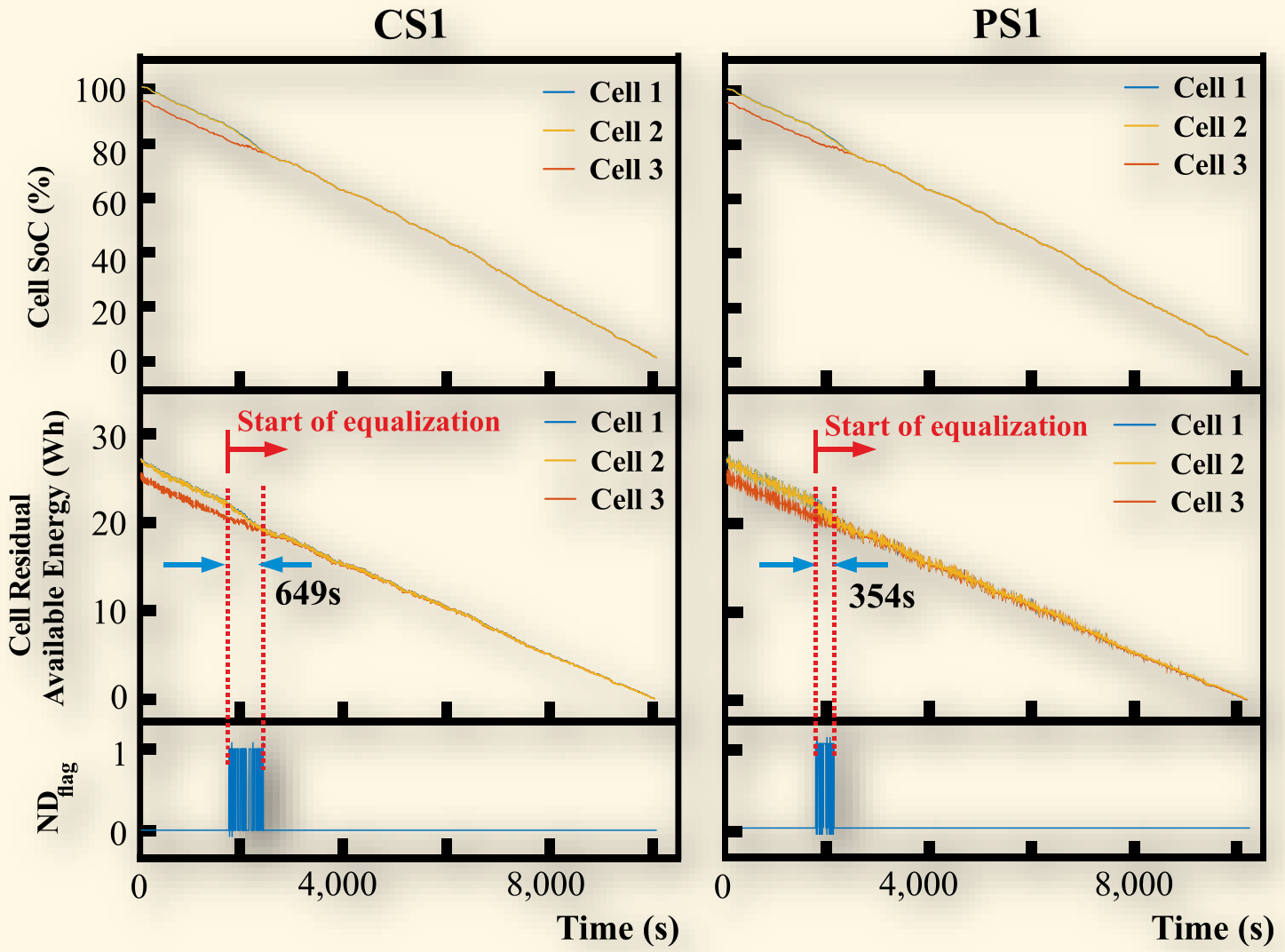


Experimental results



Experimental results

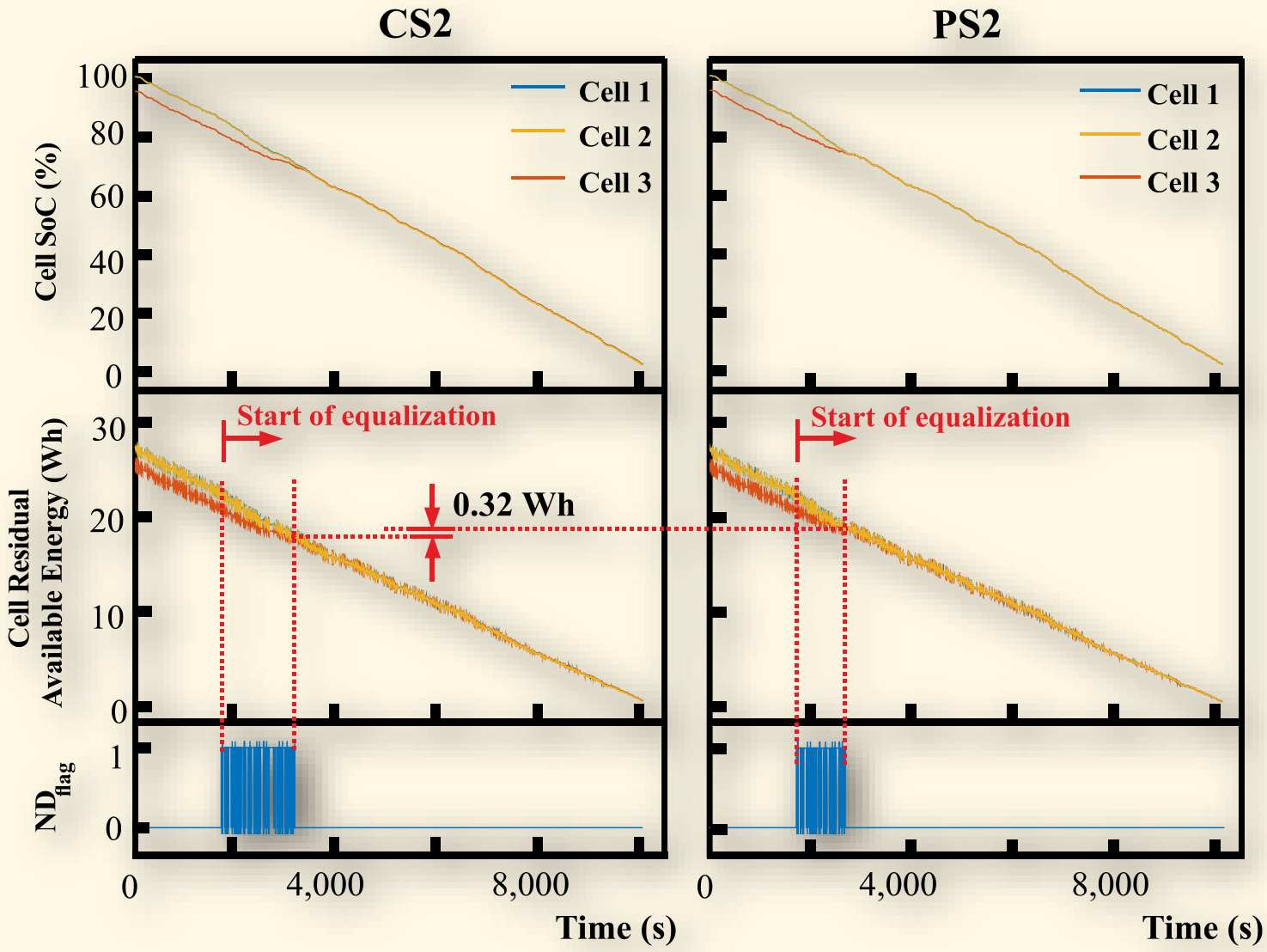
CS1:
Conventional method
The equalization current is 1C



PS1:
Improved method
The weighted factors prioritize the equalization speed

Experimental results

CS2:
Conventional method
From the Reference literature



PS2:
Improved method
The weighted factors prioritize the reduction of the power loss

Conclusions

- ***An improved battery management system*** that consists of a combined scheme of a non-dissipative equalization algorithm and an energy support algorithm
- Aim is to ***enhance the performance*** and ***protect the lifespan*** of Li-ion batteries.
- Specifically, the new control scheme properly ***regulates the equalization current*** according to the priorities that the designer of the system has imposed to attain an optimal balance between the objectives of high cell residual available energy, acceleration of the equalization procedure, and reduced power loss in the equalization converter, and also provides energy support in weak battery.
- When it is allowed by the operating conditions, the values of the ***battery cell model parameters are real-time updated***, so that improved accuracy of the control procedures is accomplished.